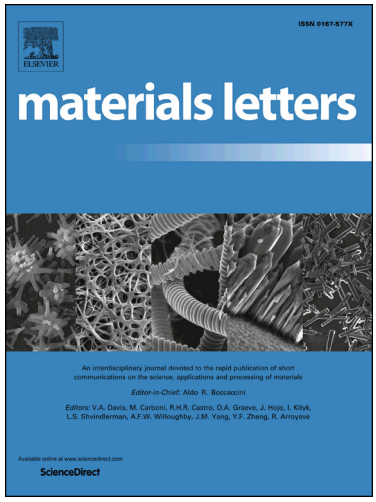

Modified Mixed Chromatography Method for Separation of Single-Walled Carbon Nanotubes based on Diameter and Conductivity

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Modified Mixed Chromatography Method for Separation of Single-Walled Carbon Nanotubes based on Diameter and Conductivity

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Abstract— Single-walled carbon nanotubes (SWCNTs) are popular for their electrical conductivity properties with excellent metallic or semiconducting behavior. Selective separation of SWCNTs can play a significant role in the realization of the potential application of SWCNTs like energy conversion and storage, electronics and biomedical applications. Gel filtration is one of the most well-known and efficient large-scale separation techniques but still complex and lengthy. In this paper, we present a very simple, efficient, and low-cost method with only four column chromatography repetitions for separation of SWCNTs using both sephacryl and agarose gels. Our results demonstrate that the small diameter semiconducting (s-) SWCNTs are adsorbed more strongly to the sephacryl gel column, while large diameter s-SWCNTs adsorbed more strongly to the column with agarose gel. Comparative optical absorption spectra of the separated nanotubes and the reference reveal the effectiveness of the presented method.

Keywords: separation, single-walled carbon nanotubes, diameter, conductivity, chromatography

1. Introduction

SWCNTs have recently attracted great interest for their electrical, mechanical and optical properties. Their applications have newly proven in energy conversion and storage such as solar cells, fuel cells, hydrogen storage, lithium ion batteries and electrochemical storage of energy [1-3] and in electronic devices such as thin-film, field effect transistors (FETs), optoelectronic and sensor systems [4-6]. Pristine SWCNTs contain both metallic and semiconducting components which can be determined by the chirality (n, m) of SWCNTs; In general, mod [(n-m),3] = 0, like (7,1), corresponds to the metallic parts and mod [(n-m),3] ≠ 0, like (6,5), (7,5), (8,4), indicates the s-SWCNTs. In any of the above-mentioned applications, the efficiency of the device strongly depends on the chirality and diameter of the utilized SWCNTs which makes their post synthesis separation an essential process. For instance, the yield of high-performance SWCNT FETs can be increased significantly by increasing the purity of 1.6-1.8 nm s-SWCNTs [6]. There have been many efforts to develop efficient SWCNTs separating methods, including dielectrophoresis [7], density gradient ultracentrifugation (DGU) [8], aqueous two-phase extraction (ATP) [9] and gel chromatography [10-16]. Among them, gel filtration is one of the most well-known separation methods for conductivity and diameter-based separation [12]. In a series of vertically connected gel columns system, Liu, et. al. reported a gel filtration process for large-scale SWCNTs separation using 10 series of six columns (60 columns) achieving up to 99% purity of s-SWCNTs in two phases [12]. In another work, a high-yield (95%) ms-separation in 7 different temperatures (between 6º-50º C) for 4 sets of dispersion, by two different surfactants has been reported [16].